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# Seasonality of nectar production by woodland plants on the Gove Peninsula

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## Abstract

In this paper I report flowering periods and indices of nectar availability over two years, for seven common plants regarded as being important nectar resources for birds in savannah woodland and rehabilitated mined land on the Gove Peninsula. Nectar availability varied seasonally, being lowest from December to February and highest in June and October each year. Nectar availability differed significantly between years, the difference being predominantly attributable to eucalypts, which exhibited large inter-annual differences in flowering, in contrast to the more consistent flowering of non eucalypts. Fern-leaved Grevillea contributed most to the nectar index (30%) across study sites. Darwin Stringybark contributed 10% to the overall nectar index, although this is considered an underestimate of its importance to nectar availability on the Gove Peninsula. Although birds were observed feeding on the nectar of all plant species for which the nectar index was calculated, Fern-leaved Grevillea (8 bird species) and Darwin Woollybutt (7 bird species) attracted the largest variety of birds.

## Introduction

Nectar is a food source for a large group of vertebrates, especially birds (particularly honeyeaters and lorikeets) and flying foxes (Pyke 1985; Woinarski *et al.* 1997). As a food source nectar is noted for its temporal and spatial variability, and this is particularly the case in the monsoon or wet–dry tropics (e.g. Franklin & Noske 1999; Williams *et al.* 1999; Woinarski *et al.* 2000). The Australian wet-dry tropics are characterised by seasonal rainfall with a distinct wet season from November to April, when approximately 85% of the mean annual rainfall falls (1713 mm at Darwin Airport, 1467 mm at Gove Airport), and a dry season from May to October. In the northern tropical savannas of Australia nectar availability peaks in the dry season associated with flowering in open eucalypt forests, especially those co-dominated by Darwin Stringybark *Eucalyptus tetrodonta* and Darwin Woollybutt *Eucalyptus miniata* (Franklin & Noske 1999; Williams *et al.* 1999; Woinarski *et al.* 2000). Darwin

Stringybark and Darwin Woollybutt both produce high energy yields of nectar, and the richest avian nectarivore community in Australia has been documented in a tropical savannah dominated by these tree species (Franklin 1994). Specialist nectarivores in this community are augmented by numerous other bird species taking advantage of the seasonal abundance of nectar (Franklin 1999).

Knowledge of fluctuations in resource availability in northern Australia is scant and mostly localised (Brooker *et al.* 1990; Woinarski & Tidemann 1991; Franklin & Noske 1999; Woinarski *et al.* 2000) and I know of no published data from the Gove Peninsula. The Gove Peninsula is approximately 650 km east of the Darwin region where most studies of flowering period and nectar availability in the Top End have taken place. The wet season on the Gove Peninsula is of similar duration but occurs later than in Darwin (Figure 1) and therefore it may be expected that there would be differences in the timing of flowering of individual species between the two locations.

In this paper I report the timing of flowering and provide indices of nectar availability for some common plants over a two-year period. These plants are regarded as important nectar sources for birds in the savannah woodland of the Gove Peninsula. These species have large flowers and were known, from the literature and from prior observations of the author and R. A. Noske, to be frequented by nectarivorous birds. Birds feeding on each of the plant species during the study period were recorded opportunistically and data are presented here. Seasonal and inter-annual comparisons of nectar availability were made and the relative contribution of eucalypts examined. Data were recorded as part of a study comparing the avifauna and their food resources of the rehabilitation areas with those of surrounding woodland on the Alcan mineral lease.

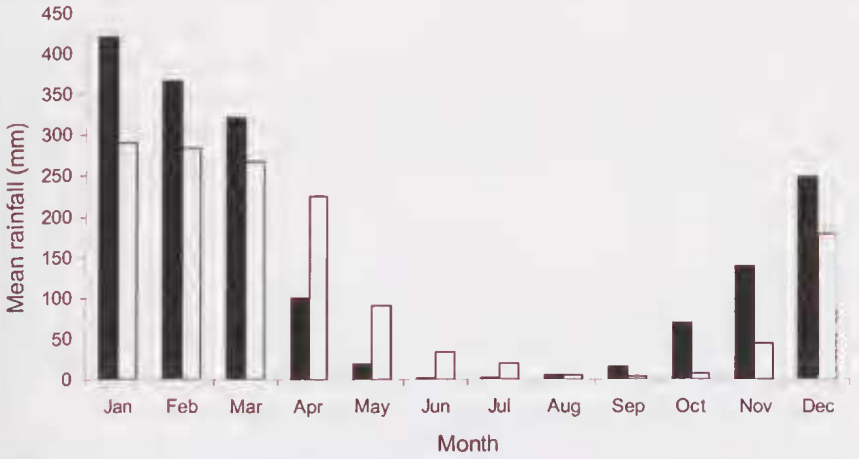


**Figure 1.** Mean monthly rainfall (mm) at Darwin Airport (black bars) and Gove Airport (white bars) (Bureau of Meteorology 2009).

## Methods

This study was conducted on rehabilitated mined land and surrounding undisturbed areas on the Alcan mineral lease on Gove Peninsula (12°16'S, 136°49'E) in north-eastern Arnhem Land, Northern Territory, Australia. Plant communities of the rehabilitated land varied from *c.* 3-8 year old shrubland (dominated by acacias, Fern-leaved Grevillea *Grevillea pteridifolia* and Red Grevillea *Grevillea heliosperma*) to low open forest (approximately 8 to 25 years old) whose canopy was dominated by Darwin Stringybark and Darwin Woollybutt (Brady 2005). The canopy of open forests surrounding the mining lease is dominated by Darwin Stringybark.

Flower abundance was observed at 36 spatially separate 30m x 30m quadrats every second month for two years between December 1998 and October 2000. Thirty quadrats were in vegetation rehabilitated by direct seeding after cessation of mining. These were spread evenly across successional stages, ranging from 3 to 25 years since rehabilitation commenced. Six quadrats were placed in the open forest adjacent to the rehabilitated vegetation.

Flower abundance was recorded for individuals of seven plant species deemed the most important for birds in the study area (Table 1); these included large and small trees and a climber. Large trees were the canopy species Darwin Stringybark, Darwin Woollybutt and Long-fruited Bloodwood *Corymbia polycarpa*. Small trees were Fern-leaved Grevillea, Red Grevillea and Red-flowering Kurrajong *Brachychiton paradoxus*. Red-flowering Kurrajong grew to considerable size in the absence of fire in rehabilitation areas, some specimens being over 8 m in height, in contrast to the stunted form common in regularly burnt woodland. Flowering of the naturalised climber Wild Passionfruit *Passiflora foetida* was also monitored.

The quantity of flowers on each individual tree was scored on a 1 to 3 scale, 1 being a small number of flowers and 3 being a large number of flowers. The size of the plant was considered in allocating scores; a small tree with many flowers may receive the same score as a large tree with few flowers. All species under study were considered when assigning scores, so that even a large, heavily flowering specimen of the Red-flowering Kurrajong would never receive a score of 3 because it was never as large as the canopy eucalypts.

To calculate an index of nectar availability that incorporates the amount of nectar produced by flowers (in addition to the number of flowers), the "expert score" of flowering intensity reported by Woinarski *et al.* (2000) was used as a multiplier (Table 1). This score was derived by asking experts to score species against each other based on their attractiveness to vertebrates, which was assumed to correlate with the amount of nectar produced by a flower and the quantity of flowers produced. (The exception was *P. foetida*, which was assigned a score after discussion with J.C.Z. Woinarski). A nectar availability index was calculated by multiplying the score of flower abundance by the expert score. Although admittedly a poor substitute for direct

**Table 1.** Observations on monitored nectar-producing plant species, with expert score and bi-monthly nectar index. Data are also given for the number of quadrats in which species were present and for the number of individuals of flowering maturity across all quadrats (except for *P. foetida*, individuals of which were not counted as it grew in a tangled mat). The number of bird species opportunistically observed feeding on each species during the study period are shown.

| | *Grevillea pteridifolia* | *Eucalyptus miniata* | *Grevillea heliosperma* | *Eucalyptus tetrodonta* | *Brachychiton paradoxus* | *Corymbia polycarpa* | *Passiflora foetida* | Total |
|---|---|---|---|---|---|---|---|---|
| No. quadrats | 18 | 25 | 18 | 17 | 16 | 5 | 15 | **36** |
| No. individuals | 100 | 86 | 66 | 56 | 68 | 11 | 0 | **387** |
| Expert score | 9.7 | 9.5 | 7 | 7 | 5.2 | 9 | 3 | |
| No. bird species | 8 | 7 | 3 | 2 | 1 | 2 | 2 | |
| **Bi-monthly nectar index** | | | | | | | | |
| Dec. 1998 | 0 | 0 | 70 | 0 | 0 | 0 | 0 | **70** |
| Feb. 1999 | 0 | 0 | 42 | 0 | 0 | 0 | 0 | **42** |
| Apr. 1999 | 0 | 95 | 280 | 0 | 0 | 0 | 0 | **375** |
| Jun. 1999 | 0 | 361 | 805 | 7 | 0 | 0 | 0 | **1173** |
| Aug. 1999 | 426.8 | 9.5 | 42 | 0 | 130 | 0 | 0 | **608.3** |
| Oct. 1999 | 1755.7 | 9.5 | 7 | 0 | 457.6 | 0 | 0 | **2229.8** |
| Dec. 1999 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | **3** |
| Feb. 2000 | 0 | 19 | 49 | 0 | 0 | 135 | 129 | **332** |
| Apr. 2000 | 0 | 731.5 | 336 | 7 | 0 | 297 | 105 | **1476.5** |
| Jun. 2000 | 0 | 2061.5 | 574 | 0 | 5.2 | 0 | 0 | **2640.7** |
| Aug. 2000 | 184.3 | 133 | 105 | 1344 | 197.6 | 0 | 0 | **1963.9** |
| Oct. 2000 | 1522.9 | 0 | 77 | 0 | 390 | 0 | 0 | **1989.9** |
| **Total** | **3889.7** | **3420** | **2387** | **1358** | **1180.4** | **432** | **237** | **12904.1** |

measurement of the amount of nectar produced by flowers, using the expert score as a multiplier includes attractiveness of flowers (nectar production) in the index of nectar availability. As the expert score also considers the quantity of flowers, the index is weighted more heavily towards the abundance of flowers than their attractiveness.

The index of nectar availability for each species for each month was calculated by multiplying the index of flower abundance (1 to 3) by the expert score for each flowering individual, and adding together the scores for all flowering individuals. Indices of nectar availability have been used in other studies of nectarivorous birds in northern Australia (e.g. Woinarski & Tidemann 1991, Woinarski *et al.* 2000).

The number of bird species feeding on flowers includes only observations of birds probing flowers in the region of the nectaries and exhibiting behaviour consistent with swallowing a liquid.

To compare nectar availability between months each quadrat was treated as a replicate and the Kruskal Wallis Medians Test was employed to test for statistical significance. To compare nectar availability between years, data for the six months of each year was pooled for each quadrat and a *t*-test for matched pairs used to test for statistical significance.

## Results

Nectar was present year round, although the amount varied seasonally, with very low nectar availability from December to February, increasing from the late wet and peaking in the dry season. The index was highest in June and October each year (Table 1, Figure 2). The difference in the index of nectar availability between months was statistically significant (Kruskal Wallis; $n = 432$, $H = 77.2$, $P < 0.001$), as was the difference in nectar availability between years (*t*-test for matched pairs, $df = 35$, $t = 3.5$, $P < 0.001$) with more nectar available in the second year. The difference between years was also significant when only data from the open forest is considered (*t*-test for matched pairs, $df = 5$, $t = 2.1$, $P < 0.05$).

Eucalypts contributed a little over half to the nectar availability index, the vast majority of which was contributed during the second dry season (Figure 2, Table 1). For non eucalypts, nectar availability followed a much more consistent pattern between years, increasing from a wet season low to a peak in October (Figure 2).

The Red Grevillea flowered most consistently, with flowers recorded in all survey periods except December 1999 (Table 1). Fern-leaved Grevillea contributed most to the nectar index across the study sites, making up 30% of the total nectar index. Fern-leaved Grevillea was recorded flowering during August and October, with a similar nectar index, in both years (Table 1). Darwin Woollybutt made the next largest contribution to the nectar index (26%). Although Darwin Woollybutt produced nectar in the dry season during both years, the nectar index was more than 6 times higher in

the second year. Darwin Stringybark and Long-fruited Bloodwood followed a similar but more pronounced pattern with little or no flowering recorded in the first year and a large flowering in the second year (Table 1). Red-flowering Kurrajong was more consistent between years and contributed to the mid to late dry season peak in the nectar index. Wild Passionfruit contributed little to nectar availability although it was the only species recorded flowering during December 1999 (Table 1).

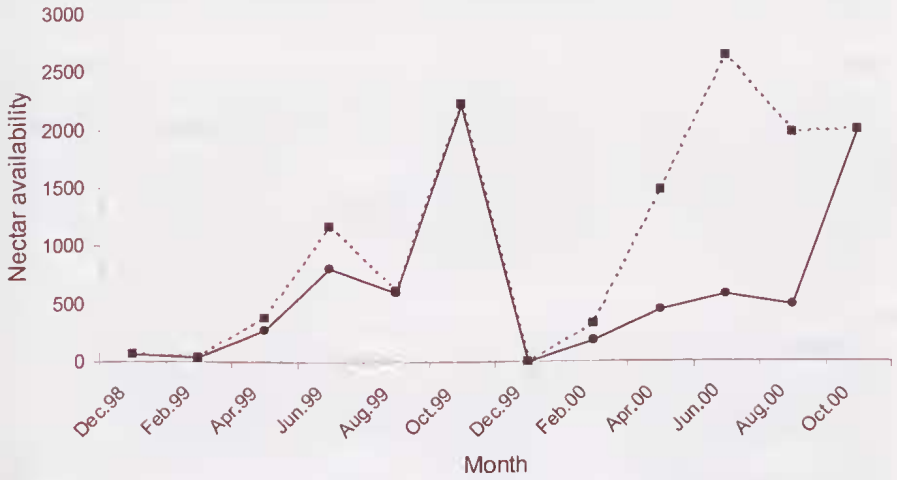


**Figure 2.** Index of nectar availability for all plant species combined (dashed line with squares) and for non eucalypt species combined (solid line with circles).

Birds were observed feeding on the nectar of all plant species for which the nectar index was calculated (Table 1). Fern-leaved Grevillea (8 species) and Darwin Woollybutt (7 species) attracted the most bird species (Table 1). Thirteen bird species were recorded drinking nectar over the study period, six of which were honeyeaters and two lorikeets (Table 2). Five species were not specialist nectarivores but were opportunistically feeding on nectar. These were Grey Butcherbird *Cracticus torquatus*, Little Corella *Cacatua sanguinea*, Spangled Drongo *Dicrurus bracteatus*, Sulphur-crested Cockatoo *Cacatua galerita*, and Torresian Crow *Corvus orru*.

## Discussion

The seasonal variation in nectar availability, with much more nectar available in the dry season, conforms to other studies from open forest and woodland in the Top End (Setterfield & Williams 1996; Franklin & Noske 1999; Williams *et al.* 1999). These results contrast with the drier more inland deciduous woodland, where Woinarski and Tidemann (1991) found flowers were present all year, but were more abundant and

diverse in the wet season and transitional months. Franklin and Noske (1999) found the dawn standing crop of nectar, in eucalypt woodland south of Darwin, varied 60-fold through the year, with a low in March and a peak flowering period from mid June to early August. The slight difference in times of peaks and troughs, later on the Gove Peninsula, may be result of the timing of the wet season, being later on the Gove Peninsula (Figure 1). The timing of flowering of one species, Fern-leaved Grevillea, was much later on the Gove Peninsula where it peaked in October compared to the June/July peak reported from woodland near Darwin (Franklin & Noske 1999, 2000).

**Table 2.** Bird species recorded feeding on nectar.

| Honeyeaters | Lorikeets | Opportunists |
|---|---|---|
| Banded Honeyeater<br>*Certhionyx pectoralis* | Rainbow Lorikeet<br>*Trichoglossus haematodus* | Grey Butcherbird<br>*Cracticus torquatus* |
| Brown Honeyeater<br>*Lichmera indistincta* | Varied Lorikeet<br>*Psitteuteles versicolor* | Little Corella<br>*Cacatua sanguinea* |
| Dusky Honeyeater<br>*Myzomela obsura* | | Spangled Drongo<br>*Dicrurus bracteatus* |
| Little Friarbird<br>*Philemon citreogularis* | | Sulphur-crested Cockatoo<br>*Cacatua galerita* |
| Silver-crowned Friarbird<br>*Philemon argenticeps* | | Torresian Crow<br>*Corvus orru* |
| White-throated Honeyeater<br>*Melithreptus albogularis* | | |

The difference in nectar availability between years is predominantly attributable to the eucalypts as they exhibited large inter-annual differences, in contrast to the more consistent flowering of non eucalypts. A statistically significant difference between years was still present when the open forest was considered separately, discounting the possibility that the difference was a result of trees in rehabilitation areas being a year older and thus more productive in the second year of the study. Although sampling occurred every second month there was no evidence (e.g. buds and fruit) that there had been an extensive flowering of eucalypts between sampling periods. Inter year differences in eucalypt flowering has been reported from other areas of the Top End, with Setterfield and Williams (1996) reporting an approximately two-fold difference for Darwin Woollybutt and three-fold for Darwin Stringybark. They reported a good flowering for each species 1 in 3 years. This pattern of among year variation in flowering has been described for many other eucalypts (Hillis & Brown 1978; Law *et al.* 2000; Birtchnell & Gibson 2006). Extended periods between flowerings may be a result of individuals needing time to accumulate sufficient resources (Ashton 1975; Birtchnell & Gibson 2006) although this does not account for the simultaneous flowering of numerous individuals.

The contribution of Darwin Stringybark to the overall nectar index (10%) greatly underestimates its importance when considering the region around the study area. The open forest and woodlands of the Gove Peninsula are overwhelmingly dominated by Darwin Stringybark. However, 30 of the 36 quadrats used to calculate the nectar index were in rehabilitation areas, thereby favouring faster maturing trees such as Fern-leaved Grevillea over slower growing eucalypts. Although the species sampled in this report would contribute the vast majority of nectar available to vertebrates in the open forest and woodlands of the Gove Peninsula, nectar would be available in other unsampled habitats such as *Melaleuca*-dominated swamps, mangroves and rainforests.

The high proportion that Fern-leaved Grevillea contributed to the nectar index is unsurprising as this species is noted for its prolific nectar production. Franklin and Noske (1999) reported nectar dripping to the ground from this species on their study site at the Territory Wildlife Park. This tree had the highest richness of bird species feeding on the nectar, including a number not usually nectarivorous, namely Grey Butcherbird, Little Friarbird, Spangled Drongo, Sulphur-crested Cockatoo and Torresian Crow. This opportunistic nectarivory has been reported from other parts of the monsoon tropics (Franklin 1999).

Long-fruited Bloodwood flowered in February and April of the second year of the study. This coincided with the presence of Banded Honeyeater and Varied Lorikeets in the study area (Brady 2005). Keast (1968) considered these two species the "blossom nomads" of the Australian woodland, and large nectar-correlated congregations have been reported in the Top End by Franklin (1996) and Woinarski and Tidemann (1991).

The consistent flowering of Red Grevillea may make it a very important source of nectar during times of low nectar abundance. Similarly Wild Passionfruit, although contributing little to overall nectar abundance, may be an important resource for resident nectarivores in times of low nectar abundance.

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Sources of nectar for birds (clockwise from above): Fern-leaved Grevillea *Grevillea pteridifolia* (TR); Red-flowered Kurrajong *Brachychiton paradoxus* (DF); Wild Passionfruit *Passiflora foetida*, an introduced species (TR); Darwin Woollybutt *Eucalyptus miniata* canopy (DF), close-up of flowers (TR).

Photographers: TR = Tissa Ratnayeke; DF = Don Franklin.

Birds at flowers (clockwise from above): Brown Honeyeater (TC); Rainbow Lorikeet (TR); Sulphur-crested Cockatoo (TR); White-throated Honeyeater (TR); Spangled Drongo (TC).

Photographers: TC = Trevor Collins; TR = Tissa Ratnayeke.